Homogeneous Group Performance in Chess

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Abstract

We performed experiments on groups of Chess programs to test the effect of group size on performance. We studied homogeneous groups (copies of the same Chess program), as opposed to heterogeneous groups (different Chess programs). Groups were made up of Stockfish. Simple Majority Voting was used to mechanically combine the individual Chess program's decisions into a group decision. Games of Chess were played between groups of increasing size, and individual Stockfish was used as an opponent. Results show that winning rate increases with group size.

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1. Introduction

Work on group superiority was carried out in 1898 by Triplett [1] who found that a group of individuals, each completing the same task, would start to compete. The additional effort by individuals resulted in the group outperforming each individual working alone. In this early work the group members were acting separately, but group superiority also exists in groups of interacting agents.

Various aspects of group performance have been studied since. Hackman and Morris [2] proposed an interaction process where “at one extreme, for example, group members may work together so badly that members do not share with one another uniquely held information … On the other hand, group members may operate in great harmony, with the comments of one member prompting quick and sometimes innovative responses in another.” In another

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study, Woolley et al [3] found that intelligence, averaged from tests on different problems, exists for groups, and “is correlated with the average social sensitivity of group members, the equality in distribution of conversational turn-taking, and the proportion of females in the group.” Also, Webber [4] concluded that younger groups were more able to improve on individual performance, and Thomas and Fink [5] concluded “group size is an important variable which should be taken into account in any theory of group behavior”.

Machine group performance was investigated in 2009 by Hanawa and Ito [6]. They used mini-Shogi as a test problem, and formed a group of machines independently searching for moves to play. The group decision was a combination of the independent decisions, and was formed by taking the majority choice. They concluded “This experiment hints at the possibility that consultation by majority is more effective than consultation by human players.”

Group intelligence has been applied to games playing. Obata et al. [8] combined the decisions of three Shogi programs using the majority algorithm, and showed that the group played a stronger game of Shogi than any of the three members as individuals. In 2000, Kasparov [9] played a game of Chess against a team whose moves were combined by plurality vote. Kasparov won the game, however, he stated that he read the team's discussion forum during the game. Marcolino et al. [10] performed a study on Go, using the same procedure as Simple Majority Voting (except that they named it Plurality Voting) and concluded that “it is possible for a team of weak but diverse agents to perform better than a uniform team made of copies of the strongest agent”.

In our work presented here, we use the terminology 'homogeneous group' to mean a group of copies of the same Chess program, as opposed to a 'heterogeneous group' which would be composed of different Chess programs. Group performance has been considered by Sato et al. [7] whose model better suits a homogeneous group.

In this work we present an investigation of machine groups and aim to answer the research question “What is the affect of group size when playing the game of Chess?”. The paper is organized as follows. Section 2 details the experimental method. Section 3 describes the results. Section 4 concludes the paper.

2. Method

We performed experiments on groups of Chess programs to test the effect of group size on performance. \( S_n \) represents a group made up of \( n \) Stockfish† Chess programs. Every Stockfish program searched with a depth limit of 11.

2.1. Simple Majority Voting

The final group decision was computed using simple majority voting as described by Obata et al. [8]. The procedure is

1. compute \( n \) candidate moves by searching with each of the \( n \) programs in the group.
2. sum the total count of each candidate move.
3. if there is a majority candidate, select it as the group move.
4. if there is not a majority candidate, use the leader’s (strongest member) proposed move to break the tie.

In our experiment we use a group made up of \( n \) Stockfish programs of equal strength, therefore, the leader of this type of group was defined as the first member added to the group.

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† The Stockfish Chess program executable was labelled as stockfish-222-sse42-ja-intel, and was downloaded from http://stockfishchess.org/download/
2.2. Winning Rate

1,000 games of Chess were played between $s_n$ and Stockfish, where $3 \leq n \leq 12$, and the winning_rate was calculated using the following formula

$$\text{winning_rate} = (\text{wins} + 0.5 \ast \text{draws})/1,000.\
$$

2.3. Denial Percentage

During the same experiments, statistics were gathered about the situations where the leader program had its proposed candidate move denied by the group majority. See Table 1.

Table 1. Enumeration of voting situations.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Leader’s candidate move accepted/denied</th>
</tr>
</thead>
<tbody>
<tr>
<td>All programs propose same move</td>
<td>accepted</td>
</tr>
<tr>
<td>All programs propose different moves</td>
<td>accepted</td>
</tr>
<tr>
<td>Leader is included in majority</td>
<td>accepted</td>
</tr>
<tr>
<td>Leader is outvoted by majority</td>
<td>denied</td>
</tr>
</tbody>
</table>

We calculated denial_percentage, where

$$\text{denial\_percentage} = \frac{\text{denials}}{(\text{group\_moves} - \text{opening\_book\_moves})}$$

Here denials is the total number of denial situations in all games played by that group (see Table 1), group_moves is the total number of moves played by the group, and opening_book_moves is the total number of moves played from the opening book for that group.

3. Results

Fig. 1 shows the winning rate of groups of different size. As can be seen in the figure, there is a peak winning rate at $s_6$ and a second peak at $s_{12}$. There is also a valley in between $s_6$ and $s_{12}$. Also, the figure shows that winning rate increases with group size.

Fig. 2 shows the denial percentage of teams of increasing size. This figure shows that a team with an odd number of members appears to have a higher denial percentage than a team with an even number of members. It also shows that the denial percentage increases as the team size increases. Peak percentage in this graph is $s_9$, however we do not have data for $s_{13}$ and greater.

There is a correlation between denial percentage and winning rate, in that both denial percentage and winning rate increase as the group size increases. However, the peak winning rates at $s_6$ and $s_{12}$ cannot be correlated with denial percentage.
Fig. 1 – Winning rate of group

Fig. 2 – Denial percentage of group
4. Conclusion

In answer to the research question detailed in the introduction, “What is the affect of group size when playing the game of Chess?” our results suggest that the winning rate increases as the group size increases. For future work we would like to investigate if the conclusion also holds true for heterogeneous Chess groups.

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References